

WATER QUALITY TESTS

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1) Alkalinity

What is alkalinity and why do we test our water for it?

Alkalinity is a measure of the ability of your water to resist changes in pH, which would tend to make the water more acidic. The pH is a value given to indicate how acidic or how basic a substance is. It is important that there is a good balance to the alkalinity of our water. In Canada, the recommended range of alkalinity is 80-120 ppm or parts per million. If the levels are higher or lower than this, there can be problems with water quality. However, alkalinity levels are usually looked at together with pH levels to get a better idea of the complete water quality.

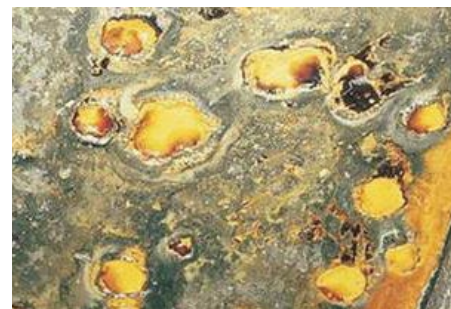


Where does alkalinity in water come from?

Alkalinity of water is due to the presence of certain ions: carbonates, bicarbonates, and hydroxides (often referred to as alkaline salts). Bicarbonates are the most common cause of alkalinity and are found in almost all natural water sources, as are carbonates. Hydroxides are found less often in natural water but concentrations may increase after certain treatments.

What happens if alkalinity is too low or too high?

If the alkalinity is too low, the ability of your water to resist pH changes decreases. This means that the pH will yo-yo up and down, changing from acidic to basic fairly rapidly. Water with low alkalinity can also be corrosive and can irritate the eyes. Water with high alkalinity has a soda-like taste, can dry out skin and can cause scaling on fixtures and throughout water distribution systems. This scaling is undesirable because it begins to decrease the efficiency of plumbing systems, which results in greater power consumption and increased costs. There do not appear to be serious adverse health effects from drinking water with alkalinity above or below the suggested levels. However, many public water utilities try to maintain an acceptable alkalinity level in order to prevent low pH (acidic) water from damaging pipelines and other distribution equipment.



Water pipes can become corroded due to water with low alkalinity and pH.

Source: http://water.me.vccs.edu/courses/ENV115/Lesson19_print.htm

What do I do if the level of alkalinity in my water is too low or too high?

Some simple household compounds can bring the alkalinity within the suggested range. In order to increase the alkalinity, baking soda (Sodium bicarbonate) can be used. To decrease the alkalinity, muriatic acid (Hydrochloric acid) can be added. We don't recommend that you do this as alkalinity problems should be dealt with in a water treatment plant.

2) pH



What is pH and why do we test our water for it?

pH is an index of the amount of hydrogen ions (H⁺) that are in a substance. The pH scale runs from 0-14, with 7.0 being neutral. Substances with a pH higher than 7.0 (7.1-14.0) are considered alkaline or basic. Substances with a pH less than 7.0 (0 - 6.9) are considered acidic. We consume many different foods and beverages with a large range of pH. For example, citrus fruits like oranges, lemons and limes are quite acidic (pH = 2.0 - 4.0). On the other hand, egg whites are a little basic, with a pH of 8.0. The ideal pH range for water is between 7.2 and 7.6. This means that the water is slightly basic. By maintaining the proper alkalinity of water, the pH will stay around the ideal levels. However, if the alkalinity gets too low, the pH can start to deviate and can begin to cause water quality problems.



What happens if the pH of my water is too low or too high?

There are no health risks associated with consuming water that is slightly acidic or basic. After all, we can eat lemons, drink soft drinks, and eat eggs. However, when water has a pH that is too low, it will lead to corrosion and pitting of pipes in plumbing and distribution systems. This can lead to health problems if metal particles are leached into the water supply from the corroded pipes. The water also has a slightly bitter and metallic taste that some may find objectionable. If the pH of your water is too high, it will have a taste similar to baking soda and will have a slippery feel to it. It will also begin to leave scale deposits on plumbing and fixtures, which will decrease the efficiency of the plumbing systems.

Type of Substance	pH Range
Battery Acid	1.1-1.7
Lemon Juice	1.9-2.8
Vinegar	3.2-3.6
Orange Juice	3.7-4.2
Cola	4.0-4.5
Normal Rainwater	5.1-5.6
Distilled Water	7.0
Blood	7.4-8.1
Baking Soda	8.3-8.8
Milk of Magnesia	9.8-10.2
Ammonia	10.7-11.5
Bleach	12.4-13.0
Household Lye	13.6-14.0

Source: http://bear_creek.tripod.com/water.htm

How do I increase or decrease the pH of my water?

Acidic water can be corrected using one of the following two methods:

1. Neutralizing filters increase the pH by passing water through a filter bed of Calcium Carbonate (CaCO₃). This neutralizes the acid and increases the pH.
2. Soda Ash (Sodium Carbonate) solution is fed through a tube into the pumping intake and is automatically injected whenever the water pump is running.

NOTE: Both Sodium and Calcium Carbonate are the most common compounds used to increase pH in drinking water.

Basic water can be corrected by either adding a specific volume of Muriatic acid (hydrochloric acid) or a commercially prepared chemical designed to decrease the pH. It is always best to check with water treatment experts when deciding on the products and the volumes to use when adjusting pH.

3) Colour

Where does the colour of the water come from?

When water has a visible tint to it, it is usually due to the presence of decaying organic material or inorganic contaminants such as iron, copper, or manganese. Limits for colour in drinking water are usually set based on aesthetic considerations. The Canadian guidelines are set at 15mg/L, as most people can easily detect colour exceeding this level. Generally, colour is classified into two types: true and apparent colour. The most common cause of true colour is decaying organic material such as dead leaves and grass. This type of colour is usually found in surface water. Apparent colour is caused by inorganic materials, usually iron, copper or manganese. The true colour of water can be distinguished from the apparent colour by filtering the sample to remove the larger organic particles. The following table lists some frequent colours that may be detected in drinking water and their most common causes.

Colour	Cause	Health Hazards/Other Problems
Red or Brown	Generally indicative of iron or manganese in water	Stains sinks and discolours laundry
Yellow	Suspended organic particles	No adverse health risks (unless chlorinated; see below)
Blue or Green	Generally due to copper in water supply or corrosion of copper pipes leading into water supply	Can cause staining of fixtures and laundry; high contents of copper (30ppm) can cause vomiting, diarrhoea, and general gastrointestinal symptoms
Cloudy, White, or Foamy	Usually due to turbidity (finely divided particles in water, either organic or inorganic)	No adverse health risks but can cause abrasions to pipes and staining of fixtures

What are the health risks associated with drinking coloured water?

Generally speaking, the colour in water does not pose any health risks. However, there are some exceptions. If the colour is due to a metal contaminant, such as copper, mild gastrointestinal symptoms may result. Therefore, Canadian guidelines stipulate certain recommended limits to many inorganic materials. Also, when chlorinated, any organic material that is present in the water can combine with the chlorine to form compounds called trihalomethanes (THMs). Chloroform is a common THM and is considered potentially carcinogenic (cancer causing). Therefore THMs in drinking water supplies that are routinely chlorinated are closely monitored and also have recommended limits.

What do I do if my water exceeds colour limits?

Colour in water can easily be removed using activated carbon filters (charcoal). However, these filters need to be replaced periodically to maintain colour absorption activity. In larger plants, a common treatment method called coagulation and sedimentation is used. This method utilizes alum and other chemicals to remove the materials that cause colouration of drinking water, before being pumped out to people's homes.

4) Heterotrophic Plate Count

What is a heterotroph?

A heterotroph is any organism that cannot make its own food and is, therefore dependent on other substances for nutrition. All animals and people, for example, are heterotrophs because we need to eat other plants and animals in order to survive. Bacteria, yeast, and moulds are also heterotrophs, as they are unable to make all the nutrients they need to live and grow. Plants, on the other hand, use the sun's energy to make their own food; therefore, they are called autotrophs.

What is the Heterotrophic Plate Count?

The Heterotrophic Plate Count (HPC) is a procedure used to estimate the number of live heterotrophic bacteria that are present in a water sample. A sample of water is put on a plate that contains nutrients that the bacteria need to survive and grow. The nutrient media that is most often used for this test is called R2A Agar, which is a gelatin-like substance that is best suited to the needs of water bacteria. After 5-7 days, the number of small spots on the plate, called colonies, is counted, and a measure of how many bacteria are present in each millilitre of water can be determined. The HPC results are generally reported as CFU/ml or Colony Forming Units per millilitre. Each colony-forming unit represents an initial single, live bacterium that was capable of multiplying until it could be observed on the plate. It is important to understand that the colony count, alone, does not allow one to draw conclusions about the risks to public health. However, it currently serves as a relatively easy way to measure filtration and disinfection efficiency, as well as the estimated numbers of bacteria in areas that have the potential for increased contamination.



What is the current Canadian limit for HPC?

Currently, the Canadian guidelines recommend that HPC levels should not exceed 500 CFU/ml. Although there are no laws enforcing this recommendation, if this level is exceeded in municipal drinking water, an inspection is often conducted to determine the cause of the increase. Often, abnormal changes in HPC can be an indication of other problems in the water system.



What are the health risks associated with high heterotrophic plate counts?

Different bacteria pose different risks to public health. Microorganisms recovered through HPC tests generally include those that are part of the natural (typically non-hazardous) microbial flora found in water. Some predominant bacterial species detected in drinking water, as well as the doses that would need to be ingested to cause an infection are outlined in the table below.

Bacterial Species	Infectious Dose (Ingested)
<i>Pseudomonas aeruginosa</i>	10^8 - 10^9 CFU
<i>Aeromonas hydrophila</i>	$>10^{10}$ CFU
<i>Mycobacterium avium</i>	10^4 - 10^7 CFU
<i>Xanthomonas maltophilia</i>	10^6 - 10^9 CFU

Common bacterial species detected in drinking water

Source: http://www.who.int/water_sanitation_health/dwq/en/HPC2.pdf

A higher risk exists for those people with a depleted immune system, such as the elderly and infants, or those with HIV. Those people on antibiotics also seem to be at an increased risk for infection following ingestion. Some of the HPC bacteria found in drinking water can cause other problems such as skin and wound infections in the community, but more often in hospitals. For example, certain bacteria are able to grow in large numbers on catheters used in hospitals and are capable of causing an infection at the point where the catheter is inserted.

It is important to state that not all bacterial species fall under the HPC category and several bacteria that are not routinely found in drinking water can present serious public health risks. See the waterborne pathogens fact sheet for a complete list of those bacteria that can cause illness in humans.

What do I do if my water exceeds HPC limits?

Growth of bacteria following drinking water treatment is normally referred to as re-growth. This type of growth is typically reflected in higher HPC values measured in water samples. Re-growth generally occurs in areas of distribution or plumbing systems where the water may remain stationary for a longer amount of time, in bottled water, water softeners or carbon filters. In order to ensure that re-growth of bacteria is kept to a minimum, general water safety practices such as maintenance protocols, regular cleaning, temperature management and maintenance of a disinfectant residual (e.g. chlorine) should be in place. If the HPC points exceed recommendations, one should consider looking at whether the system has been adequately cleaned, whether the disinfectant residual is effective, and the efficiency of temperature management. A failing in any of these areas could lead to elevated HPC levels.

5) Residual Chlorine

What is Residual Chlorine and why do we test for it?

Chlorine is a chemical that is used to disinfect water prior to it being discharged into the distribution system. It is used to ensure water quality is maintained from the water source to the point of consumption. When chlorine is fed into the water, it reacts with any iron, manganese, or hydrogen sulphide that may be present. If any chlorine remains (residual), it will then react with organic materials, including bacteria. In order to ensure that water is sufficiently treated through the whole distribution system, an excess of chlorine is usually added. This amount is usually adjusted to make sure there is enough chlorine available to completely react with all organics present. The chlorine will decrease in concentration with distance from the source, until it reaches the point where the chlorine level can become ineffective as a disinfectant. Bacteria growth will occur in distribution systems when very low levels of chlorine are encountered. Therefore, it is important to make sure there is enough chlorine to efficiently disinfect even at the far ends of the distribution system. Chlorination can kill many pathogenic (disease causing) microorganisms such as E.coli, but others, like Cryptosporidium and Giardia, are very resistant to chlorine and require other measures to properly remove them.

There are some important chlorination trends found in drinking water treatment:

- As chlorination increases, the time required to disinfect decreases.
 - Chlorination is **more** effective as the temperature increases.
- Chlorination is **less** effective as pH increases (becomes more alkaline).
Chlorination is **less** effective in turbid water.

Residual chlorine may have a taste and/or odour that some people may find disagreeable. However, most would prefer that to drinking water that contains potentially harmful inorganic and organic materials.



What are the current Canadian recommendations for residual chlorine?

There are two ways in which residual chlorine is measured. Free Chlorine is the chlorine that remains in the water that has not reacted with anything (organic or inorganic). Total Chlorine is the chlorine that remains in the water that is both free and reacted.

The Federal-Provincial-Territorial Committee on Drinking Water recommends a minimum Free Chlorine residual of 0.1mg/L or a minimum Total Chlorine level of 0.5mg/L.



What are the health risks associated with low residual chlorine?

Studies have shown that when residual chlorine levels drop below recommendations, several water quality problems can occur. With regard to public health, bacteria and selected viruses, called bacteriophage, are able to multiply in water that is not properly disinfected and, depending on the species, could potentially cause waterborne illnesses.

It is important to note that, although chlorination has been the most common method of disinfection for over 100 years, there have been recent studies that have shown that chlorine in water can react with otherwise innocent organic material in drinking water and form chemicals called Trihalomethanes (THMs), such as chloroform. THMs have been shown to be potentially carcinogenic (cancer causing) and are, therefore, carefully monitored in water systems that are routinely chlorinated. While recommendations only state minimum residual chlorine levels, it is important that a careful balance is maintained in drinking water. There needs to be enough chlorine to make sure everything is properly disinfected. However, an extreme excess of chlorine is not necessary and may lead to high levels of THMs and the adverse health risks described previously.

What do I do if my water does not meet residual chlorine recommendations?

In municipal water systems, the drinking water is chlorinated prior to being distributed and chlorine residuals should be measured at the far end of the distribution line. This ensures that the house located furthest from the plant still receives water that is adequately disinfected. If your water does not have appropriate chlorine residual levels, contact your local treatment facility and have them conduct further tests to make sure enough disinfectant is added to the water at the plant. For homes that get their water from wells, either commercial disinfectants or diluted household bleach may be used to adequately treat drinking water. Usually, gaseous chlorine is added to the water at large treatment facilities. However, this form of chlorine is too dangerous to be used for home use and other disinfectants such as those mentioned above are recommended. Contact a local water treatment authority to determine the recommended levels for your well system.

6) Sulphate

What is sulphate and why do we test for it?

Sulphur is a non-metallic element that is widely used for commercial and industrial purposes. Sulphur combines with oxygen to form the sulphate ion, SO_4 . Sulphate products are used in the manufacture of many chemicals, dyes, soaps, glass, paper, fungicides, insecticides, and several other things. They are also used in the mining, pulp, sewage treatment and leather processing industries. Aluminum sulphate (alum) is used in water treatment as a sedimentation agent, and copper sulphate has been used to control blue-green algae in raw and public water supplies.

Drinking water with excess sulphate concentrations often has a bitter taste and a strong 'rotten-egg' odour. Sulphate can also interfere with disinfection efficiency by scavenging residual chlorine in distribution systems. Sulphate salts are capable of increasing corrosion on metal pipes in the delivery system and sulphate-reducing bacteria may produce hydrogen sulphate which can give the water an unpleasant odour and taste and may increase corrosion of metal and concrete pipes.

What are the current Canadian limits for sulphate?

The current limits for sulphate in drinking water are based on aesthetic objectives and are set at $<500\text{mg/L}$, which is the taste threshold level.

What are the health risks associated with high or low sulphate levels?

There are no symptoms associated with sulphate deficiency. However, most people get the majority of their dietary sulphates through food and not from the water. High sulphate levels (1000 mg/L) have been shown to have a laxative effect on humans and can cause mild gastrointestinal irritation. Therefore, excessively high sulphate levels are usually investigated by water treatment authorities.



What do I do if my water exceeds the recommended sulphate limit?

Unfortunately, sulphate is not easily removed from drinking water as it is often in a form that is quite soluble in water. The most effective removal methods include distillation, reverse osmosis or electrodialysis. For home treatment reverse osmosis and distillation are most common.

7) Nitrate

What is nitrate and why do we test for it?

Nitrate (NO_3) is a compound of nitrogen and oxygen that is found in many everyday food items such as spinach, lettuce, beets, and carrots. There are usually low levels of nitrates that occur naturally in water but the majority run-off from, animal feedlots, wastewater and sludge, septic systems, and nitrogen fixation from the atmosphere by legumes, bacteria, and lightning. Nitrate in water is colourless, tasteless, and odourless. Therefore, it can only be detected using chemical analysis.

What are the current Canadian limits for nitrate?

The current Canadian limit is 45mg NO_3/L (10 mg $\text{NO}_3\text{-N}$). Above this level, an alternate source of water should be available for infants under 6 months of age.

What are the health risks associated with high nitrate levels?

There are a few potentially serious health risks associated with drinking water high in nitrates. The most serious is Methemoglobinemia (Blue-Baby Syndrome), which occurs most often in infants under 6 months of age. Nitrate becomes toxic when it is reduced to nitrite. This process can happen both in the saliva and in the stomach. The stomach acid of infants is less acidic than in adults and is, therefore more conducive to the growth of nitrate-reducing bacteria. The nitrate is reduced to nitrite in the blood and then combines with haemoglobin to form a compound called methemoglobin. Methemoglobin is not as efficient as haemoglobin at carrying oxygen to body tissues so oxygen deprivation results. If an infant is affected by Methemoglobinemia, the skin around the mouth and on the extremities will turn blue and the child will experience shortness of breath. Severe Methemoglobinemia can result in brain damage and death. However, if the symptoms are recognized and medical help is sought immediately, the condition can be easily treated with an injection of methylene blue.



The majority of Blue Baby Syndrome cases have occurred at nitrate levels over 100mg/L. Healthy adults can consume large amounts of nitrate without suffering adverse health effects. The nitrate consumed daily in the diet is readily absorbed and is excreted as urine. However, prolonged ingestion of high levels of nitrate has been linked to stomach problems and may increase risk of bladder cancer.

What do I do if my water exceeds the recommended nitrate limit?

Boiling drinking water will not decrease its nitrate concentration. In fact, the nitrate concentration will actually increase because of the evaporation of the water. Water that exceeds the recommended nitrate levels should not be consumed, in any way, by infants under 6 months old. Charcoal filters and water softeners are also not adequate treatment methods for elevated levels of nitrate in drinking water. Several treatment options do exist and these include the following:

- Distillation
- Reverse osmosis
- Ion-Exchange
(Nitrate ions are exchanged for something else, such as chlorine)

Contact your local water treatment authorities to find out which method would be right for your water system.



8) Ammonium

What is ammonia and why do we test our water for it?

Ammonium is a reduced form of nitrogen (NH_4^+) and together with the non-ionized form (NH_3) they compose ammonia. Ammonia is frequently present in groundwater sources where there is no oxygen present. Ammonia ions play a key part in water treatment because they need to be removed before breakpoint chlorination can be achieved. Breakpoint needs to be reached to comply with Canada's primary disinfection requirements.

Where does ammonia in water come from?

Ammonia comes from the breakdown of plants and animals, agricultural (application of large quantities of ammonia fertilizer), and industrial processes. The use of ammonia-containing groundwater and chloramination can also contribute to the ammonia levels. Groundwater that is anaerobic (no oxygen) can contain large quantities of ammonia ($>2 \text{ mg/L}$) while surface water sources generally contain levels ten times lower. During specific events in a lake, such as the death of an algal bloom, or spring and fall turnover (when bottom waters get mixed in with the surface water layer), the ammonia levels can increase although it is typically decreased quite rapidly. Also intensive livestock operations can contribute large quantities of ammonia to surface water sources. High levels of ammonia in surface waters can therefore be an indicator of pollution by various sources.



Picture1. Cattle grazing around a water source. What contaminants do you think will end up in the water under these circumstances? Do you think this is healthy for the cattle?

What are the current drinking water quality guidelines for ammonium?

There is no guideline for ammonia in the U.S. or Canada, but the European Union recommends that ammonia levels should be lower than 5 mg/L . However, as discussed here, such high levels would basically exclude the use of chlorine as a primary disinfectant. Unfortunately, many communities don't realize this and are not adequately disinfecting their water.

What happens if ammonia levels are too high?

There are no health based guidelines for ammonia in drinking water, but its removal is recommended as ammonia can compromise disinfection, it can cause taste, odour and the formation of nitrite as well as interfering with the removal of manganese. Strong oxidizing reagents, such as ozone, chlorine dioxide, chloramines and potassium permanganate cannot remove ammonia ions while chlorine will remove the ammonia by forming less toxic compounds, the chloramines. However, for every mg of ammonia removed, the chlorine demand is 10-15 mg.

The use of chlorine for ammonia removal can only be recommended for water sources with less than 1 mg/L of ammonia (preferably less than 0.2 mg/L). If breakpoint chlorination is not achieved then the water treatment plant is using what is called secondary disinfection, which should only be used after primary disinfection has been carried out.

An ideal and inexpensive way of oxidizing the ammonia to nitrate is achieved by biological treatment where bacteria (nitrifiers) gain energy from the conversion of ammonia to nitrate. Initial problems of biologically removing ammonia at low temperatures (bacteria generally like warmer temperatures) have been overcome as shown by Yellow Quill First Nation where the oxidation of 4 mg/L of ammonium down to levels less than 0.05 mg/L is achieved at 6°C using a rapid filtration process (see www.safewater.org for more information on biological filtration).

What do I do if the level of ammonium in my water is too high?

We don't recommend that action is taken in individual homes as these are issues that should be dealt with in the water treatment plant.

9) Iron

What is Iron and why do we test for it?

Iron is the fourth most abundant element in the earth's crust. Iron is a very common problem in drinking water and has a strong relationship with water hardness (see Hardness tests) typically with both hardness and iron increasing at the same time. Iron can cause staining (laundry and plumbing), unpleasant taste, colour and promotion of growth by iron bacteria. Iron can also precipitate in distribution systems and household plumbing thereby causing additional problems.

When there is no oxygen in the water then the iron is present in a reduced, dissolved form (Fe^{2+}), which is frequently present in well water. This form of iron is dissolved and has no colour. When this iron is exposed to oxygen it will oxidize and this iron (Fe^{3+}) is not very soluble and instead forms small particles or colloids. These rust particles are red in colour and are quite small making it a challenge to remove them. Both sedimentation and filtration are commonly used methods to remove oxidized iron.

Bacteria can use reduced iron as an energy source by converting it to oxidized iron. The biologically oxidized iron is then incorporated into compounds around or in the bacterial cells. This can cause problems in restricting water pipes. However, this bacterial growth can also be used in the water treatment plant to remove iron from the water. This is called biological filtration where bacteria are sitting on a surface (can be sand or different forms of material that have been designed with high surface areas).

What are the Canadian Drinking Water Guidelines for Iron?

Based on aesthetic reasons the Guidelines for Canadian Drinking Water Quality recommends that the iron levels should be kept below 0.3 mg/L. However, levels as low as 0.100 mg/L can cause problems with microbial growth within Reverse Osmosis and other types of membrane systems as well as in the distribution systems. The U.S. Environmental Protection Agency's Maximum Contaminant Level (MCL) is also 0.3 mg/L. The major source of iron is food (around 10 mg/day), while drinking water typically contributes less than 0.5 mg/day.

What are some of the health risks associated with Iron?

Iron is an essential element for humans with food providing the majority of the iron requirements. There should be no direct health effects with iron in drinking water, but iron can be linked to excessive bacterial activity. The end result of this action is water that is not pleasant to drink (smell and taste), cooking with this water can also lead to a very unpleasant experience, as will using it to do laundry or wash with.

What do I do if my water exceeds the Canadian Drinking Water Guidelines?

Iron can be removed by biological filtration as shown above (chemical-free iron removal) or various forms of oxidants including air, potassium permanganate and chlorine can be used to form oxidized iron, which can then be filtered from the water. If the iron is generated in the distribution system then the corrosiveness of the water (see Alkalinity and Hardness tests) may have to be decreased (that is alkalinity and hardness increased). Iron removal water treatment processes are frequently used for groundwater treatment while particulate oxidized iron sometimes present in surface water will be removed by coagulation processes (bunching up small particles that can be removed when particle size increases).

10) Copper

What is copper and why do we test for it?

Copper is a metal that is naturally present in the environment, but the levels of contamination can be increased around agricultural land (manure spreading), near smelting facilities, and phosphate fertilizer plants. There are also significant amounts of copper released from wastewater treatment plants, which could lead to problems downstream for a community that uses this water as their source water. Farmers and others that rely on small water reservoirs for their water supplies may at times try to control algal blooms with copper sulphate (bluestone), which can increase the copper levels in their water supplies. But, as copper is taken up by the algae its levels should decline rapidly.

However, the main source of copper comes from household plumbing especially when the water is corrosive. As the copper levels in the water treatment plant is generally acceptable, compliance with the copper Guideline is generally achieved by controlling the corrosiveness of the water in the treatment plant. The corrosiveness of water towards copper is generally highest when the water is acidic (pH less than 7, see pH Test), the Alkalinity is low (see Alkalinity Test), and the Hardness is low (see Hardness Test).

What are the Canadian Drinking Water Guidelines for Copper?

The guidelines state that the level should not exceed 1 mg/L Copper. The U.S. Environmental Protection Regulation for Copper is 1.3 mg/L. The World Health Organization has established a 2.0 mg/L guidance level.

What are some of the health risks associated with Copper?

Copper is an essential nutrient, required by the body in very small amounts. However, health effects may occur when people are exposed to it above the guideline level. The National Academy of Sciences' Food and Nutrition Board recommends that children need at least 0.34 mg Copper/day and adults need 0.9 mg Copper/day. It also recommends that consumption should not exceed 9 mg Copper/day.

The most common health effects of the excessive consumption of copper bearing water would be; nausea, vomiting, diarrhea, upset stomach, and dizziness. If extreme intake of copper occurs, kidney and liver damage is possible.

What do I do if my water exceeds the Canadian Drinking Water Guidelines?

Since the major contributor to copper in drinking water is the corrosion of the copper pipes, the best way to minimize the problem is to raise the pH of the water to greater than 7.0 so that the piping is not being attacked. Another possibility is that the source water may be contaminated by one of the sources previously stated; in that case a more aggressive approach may be needed by the water treatment facility. Actions to ensure that we are not exposed to high levels of copper should all be taken at the drinking water treatment plant.

If the water is corrosive, higher levels of copper can occur when the water sits in plumbing pipes for longer periods, such as overnight. Flushing of the tap water for 30 seconds or more can reduce the copper levels.

In the U.S. if a water system fails to comply with the U.S. Environmental Protection Agency Regulation it must notify the public through newspapers, TV etc. Failure to provide water meeting the Copper Standard may mean that the water supplier needs to supply alternate drinking water supplies.

11) Manganese

What is manganese and why do we test our water for it?

Manganese is a grayish hard white metal resembling iron. Drinking water guidelines for manganese are set for aesthetic reasons as manganese can stain plumbing and laundry as well as imparting taste and odour to the water. Manganese-containing water can react with coffee, tea and even alcoholic beverages producing a black sludge affecting both taste and appearance. In addition, commonly occurring dissolved manganese (Mn^{2+}) can be oxidized (Mn^{4+}) by bacteria encouraging microbial slime formation in both distribution and household pipes.

Where does manganese in water come from?

Manganese is leached out of rocks and minerals as well as man-made materials, such as iron and steel pipes. Groundwater supplies having been in contact with rocks for long periods of time generally have much higher levels of manganese than surface water sources. Sometimes discharge of acidic industrial wastes or mine drainage can increase manganese problems in affected surface water sources. Manganese can also be found in many food items, including grains and cereals as well as being quite high in tea.

What are the current drinking water quality guidelines for manganese?

The Guideline for Canadian Drinking Water Quality states that staining of plumbing and laundry occur above 0.15 mg/L manganese; for most individuals 0.05 mg/L of manganese is objectionable in terms of taste and this level, 0.05 mg/L, has been set as a manganese guideline both in Canada and the U.S. This level is identical to that set as a maximum acceptable concentration (MAC) in Europe, but in Europe a guideline level of 0.02 mg/L has also been adopted. Manganese can, however, at high levels, cause damage to the brain, liver, kidneys, and the developing fetus. Some drinking water supplies in North America contain 10-100 times the current guideline value.

What happens if manganese levels are too high?

Some of the most common water treatment processes for groundwater are designed to remove manganese to below guideline levels. In conventional treatment reduced manganese (Mn^{2+}), which is soluble, is oxidized to Mn^{4+} , which is insoluble, and the Mn^{4+} is then filtered out (Mn^{3+} may also be formed). The oxidation of Mn can take place with oxygen (pure or air), chlorine, ozone, potassium permanganate etc. It is also possible to oxidize the manganese with bacteria in biological filters. If the raw water contains a lot of organic material, ammonium and other interfering compounds, then the oxidation may be incomplete and manganese may still be present in high levels in the treated water. Under these conditions bacteria are encouraged to grow within distribution lines and household plumbing forming microbial slimes.

What do I do if the level of ammonium in my water is too high?

We don't recommend that action is taken in individual homes as these are issues that should be dealt with in the water treatment plant.

12) Arsenic

What is arsenic and why do we test our water for it?

Arsenic occurs naturally often together with other chemicals in soils and minerals. Arsenic and all of its compounds are poisonous, but the toxicity varies. Inorganic arsenic is thought to be most toxic; it can occur as trivalent arsenite (As^{3+}) or pentavalent arsenate (As^{5+}). These are the types of arsenic present in drinking water. Organic arsenic is mainly found in seafood and is much less harmful to human health. The guideline for arsenic has decreased from 50 micrograms per L to 25 and this year it has decreased further to 10 micrograms/L. As we know more about the ill effects of arsenic it is expected that it will decrease further. The Safe Drinking Water Foundation recommends that efforts should be made to keep treated water levels below 5 micrograms/L.

Where does arsenic in water come from?

In Canada arsenic concentrations in underground water sources (well water, aquifer water) are higher than surface water supplies, which is common to most locations around the world suffering from arsenic problems. If you live in an area that is known to have high arsenic levels then you should have the water tested.

What happens if arsenic levels are too high?

Arsenic testing is now becoming more common for municipal water treatment plants to carry out. Check with your local drinking water treatment plant if its water has been tested for arsenic. For people that have had longer term exposure to elevated arsenic levels, medical doctors may prescribe tests that analyze arsenic levels in urine, blood and hair. Arsenic can cause a large number of ailments including cancer. Most countries around the world are now starting to realize the grave health implications of arsenic contaminated water sources and are taking measures to prevent the consumption of above guideline levels of arsenic.

What do I do if the level of alkalinity in my water is too low or too high?

For people on municipal water supplies the arsenic levels should normally be tested regularly and efforts are generally made to improve and optimize water treatment methods so that arsenic levels remain below Guideline levels. However, as the acceptable level of arsenic is decreasing, it is becoming increasingly difficult to remove arsenic to trace levels without the use of some form of advanced treatment systems. The introduction of Reverse Osmosis membranes can remove high levels of arsenic (>75 micrograms/L) to levels below 2 micrograms/L. If the arsenic is in the form of arsenite (As^{3+}) it will not be effectively removed even by RO membranes. It is therefore necessary in high arsenic water sources to make sure that the arsenite is converted to arsenate before the water is treated by RO.

13) Total Hardness

What is total hardness and why do we test our water for it?

The Guidelines for hardness are based on aesthetic, rather than health concerns. Hard water causes scale to form in water pipes, plumbing fixtures and kitchen appliances (see photo). Scale build-up in hot water tanks and boilers increases heating costs and can lead to premature failure of heating equipment. Scale deposited in clothing during washing will cause increased wear and tear on fabrics. Soap reacts with hard water to form a curd and can also cause skin flaking and irritation. In addition, when washing or doing laundry with hard water, more soap or detergent is needed.

Where does hardness in water come from?

Hardness is primarily caused by the dissolved mineral compounds calcium and magnesium although smaller contributions to hardness will also come from some other ions including iron and manganese. The amount of hardness is expressed in milligrams per litre (mg/L) or grains per gallon (gpg) as calcium carbonate.

Hardness is calculated from the equation $\text{Hardness} = 2.497 \cdot \text{Ca} + 4.118 \cdot \text{Mg}$. Therefore, fluctuations in the magnesium pool affect hardness stronger than do calcium fluctuations.

The main components of hardness, calcium and magnesium, are actually of benefit to people. There are no Canadian guidelines for calcium in water and when present in drinking water, calcium may be considered to be of nutritional benefit (if levels around 50 mg/L were consumed, drinking water would provide around 5 to 10% of the daily calcium requirements). The European Community has set a guideline level of 100 mg/L with no maximum acceptable upper concentration. The European Union has also stated that water intended for human consumption should contain a minimum of 20 mg Ca/L.

Magnesium is an essential nutrient for humans, with adults requiring around 350 mg/L per day. Moderate levels of magnesium may provide a nutritional benefit to individuals consuming a magnesium deficient diet. There are no Canadian recommendations in regard to magnesium, but the European Community suggests a guideline of 30 mg/L, with a maximum acceptable level of 50 mg/L, which may be related to magnesium's strong effect on hardness and has no health significance.

What do guidelines say about hardness?

The *Guidelines for Canadian Drinking Water Quality* notes the following:

- 1) public acceptance of hardness varies considerably. Generally hardness levels between 80 and 100 mg/L as CaCO_3 are considered acceptable;
- 2) levels greater than 200 mg/L are considered poor but can be tolerated;
- 3) levels in excess of 500 mg/L are normally considered unacceptable;
- 4) where water is softened by sodium-ion exchange, it is recommended that a separate unsoftened supply be retained for culinary and drinking purposes.

The Saskatchewan Government has set an upper acceptable limit for hardness to 800 mg/L. Such high levels will, however, impart a taste to the water and will cause problems with clothes washing, minerals will be deposited on dishes, tubs and showers and water heaters will become less efficient.

What happens if the hardness is too low or too high?

If the hardness is too low the water can be quite corrosive leaching out copper and lead of plumbing pipes. With very low hardness there would also be low levels of beneficial ions in the water especially calcium and magnesium. If hardness is too high it can have an unpleasant taste, can dry out skin and cause scaling on fixtures and throughout the water distribution system. This scaling is undesirable because it begins to decrease the efficiency of plumbing systems, which results in greater power consumption and increased costs.

What do I do if the level of hardness in my water is too low or too high?

Public water utilities with high hardness levels may not be able to lower these levels as it is difficult to do this and an increased use of membrane technologies will become common in the future. These membranes, such as nanofiltration membranes and reverse osmosis membranes can effectively remove both calcium and magnesium ions from the water (the main causes of hardness). However, when using Reverse Osmosis (which removes virtually all calcium and magnesium ions) it should be borne in mind that the European Union has stated that water intended for human consumption should contain a minimum of 20 mg Ca/L. RO treated water frequently fails to meet this guideline unless calcium is added back to the water. In homes the use of softeners is more common where calcium and magnesium ions are replaced by sodium or potassium, although many homes are now installing under the sink reverse osmosis membranes to provide drinking water.